On a New Form of Altazimuth. By W. H. M. Christie, M.A., F.R.S., Astronomer Royal.

The altazimuth proposed is a reversible transit-circle with iron stand, capable of being placed in different definite azimuths, say 0°, 20°, 40°, 60°, 75°, 90° E. or W. of the meridian, the instrument being used as a transit-circle in any one of these azimuths. This may be arranged by mounting the iron supports of the transit-circle on a circular base resting at three parts of its circumference on a circular casting carefully planed on its upper surface and bolted to the foundation pier. By the help of friction rollers, brought into action to take off part of the weight, the transit-circle could be rotated round a central pivot from one definite azimuth to another, suitable arrangements being made for locking it firmly in the required position, as in the case of a railway turntable. In fact, the transit-circle would be mounted on a turntable with provision for bringing it into definite azimuths and for securing its fixity when brought into position. The proposed altazimuth would thus be essentially a transit-circle capable of being used out of the meridian, in the prime vertical or in any other selected azimuthal plane. It would differ in principle from the well-known form of transit-instrument in the prime vertical, as the zenith-distance of the object would be observed (by means of the vertical circle) as well as the time of azimuthal transit, and a complete determination of the position of the object (R.A. as well as N.P.D.) would be made by a method of observation and reduction essentially different, and applicable in any azimuthal plane.

The principle of the method of observing would be that the observations of azimuth and zenith-distance should be referred to the same instant of time and that from these the R.A. and N.P.D. would be deduced subject to corrections for the instrumental errors of collimation, level and azimuth (difference from assumed azimuth).* The computations would thus be greatly simplified, and tables could be readily formed for the given azimuths of auxiliary quantities which would render the reductions very easy.

Transits should be taken over vertical wires (say two sets of five, omitting the central wire), and over horizontal wires (say two sets of five, omitting the central wire) arranged so that, generally, the horizontal and vertical transits would not interfere with each other, and that the mean of the time of transits over the vertical and horizontal wires respectively would differ only by a small quantity. This condition may be secured by having in addition to the systems of vertical and horizontal wires (each carried on a micrometer slide as usual in a transit-circle) a wire

* The observed Z.D. and time of transit might be corrected for the effect of errors of collimation and level before the computation of N.P.D. and R.A., but the corrections would, I believe, involve a little more labour.

carried by a position-circle micrometer, which would be set to the approximate inclination of the path of the object to be observed. The telescope having been set to the computed Z.D. and clamped, when the object enters the field it is to be bisected (approximately, with allowance for curvature of path if necessary) by the position-circle wire by means of its micrometer screw, or by the slow motion in Z.D., and the middle horizontal wire is to be made to bisect this wire at its intersection with the middle vertical wire by means of the Z.D. micrometer. The object should thus transit simultaneously over the middle horizontal and vertical wires and the means of the times of transit over the two sets of wires would not differ by more than a very small quantity, say δt.

[As an alternative method of observing the Z.D., the object might be bisected by the wire of the position micrometer (set to the approximate position angle of the diurnal path) at its transit over the middle and pairs of vertical wires, as in zenith-distance observations with a meridian transit-circle.]

Let t, $t+\delta t$ be means of times of transit over the vertical and horizontal wires respectively, z' the observed zenith distance (corrected for refraction and parallax), $z = z' - \delta z$ the Z.D. at time t.

A the assumed azimuth (not greater than 90°, and reckoned positive from South towards West), γ the co-latitude, h the hour angle (in arc), Δ the N.P.D., and S the parallactic angle.

Then we have,

$$\delta z = 15 \sin S \sin \Delta \delta t = 15 \sin \gamma \sin A\ \delta t = 15 m\ \delta t$$

where

$$m = \sin \gamma \sin A, \text{ a constant for a given azimuth,}$$

whence

$$z = z' - \delta z \text{ is known.}$$

Therefore, putting

$$\tan \theta = \tan \gamma \cos A,$$

and

$$n = \frac{\cos \gamma}{\cos \theta}$$

where θ and n are constants

$$\cos \Delta = \frac{\cos \gamma \cos (z+\theta)}{\cos \theta} = n \cos (z+\theta) \tag{1}$$

$$\sin h = \frac{\sin A \cdot \sin z}{\sin \Delta} \tag{2}$$

which give the N.P.D. and hour angle, uncorrected for instrumental errors. Also the parallactic angle is given by

$$\sin S = \frac{\sin \gamma \sin A}{\sin \Delta} = m \operatorname{cosec} \Delta.$$

It has been assumed so far that the object was observed at the assumed azimuth A at time t, and corrections for errors of

collimation (c), level (l), and azimuth (a), must now be applied to Δ and h viz.:—

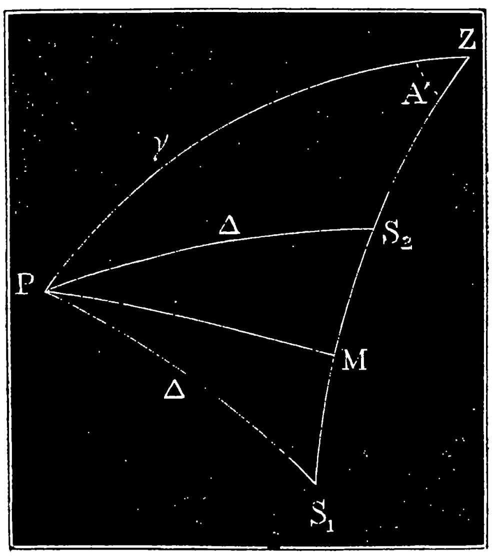
Collimation	$\delta\Delta = c \sin S$	$\delta h = c \cos S \operatorname{cosec} \Delta$
Level	$\delta'\Delta = l \cos z \sin S$	$\delta' h = l \cos z \cos S \operatorname{cosec} \Delta$
Azimuth	$\delta''\Delta = a \sin z \sin S$	$\delta'' h = a \sin z \cos S \operatorname{cosec} \Delta$

The factors $\sin S$, $\cos z \sin S$, $\sin z \sin S$, $\cos S \operatorname{cosec} \Delta$, $\cos z \cos S \operatorname{cosec} \Delta$, $\sin z \cos S \operatorname{cosec} \Delta$ may be tabulated to three places of decimals for the given azimuths, and at convenient intervals of Z.D. or N.P.D., but probably only two places of decimals would be required in most cases, so that the corrections would be very easily made.

Thus the N.P.D. and hour angle are determined, and from the latter in combination with the time of transit the R.A. of the object is at once obtained if the clock error is known. Reciprocally, the clock error would be found from observations of clock stars, the R.A. of which is known.

It remains to consider the determination of the zenith point and of the errors of collimation, level, and azimuth.

The zenith point would be usually determined by the nadir observation of the middle Z.D. wire reflected in a mercury trough. In the meridian it would also be found from reflection observations of stars and the R—D correction deduced. The collimation error would be determined by the nadir observation of the reflected azimuth wire in reversed positions of the transit-circle. This would be checked by observations of collimators in the meridian, and also, perhaps, in the prime vertical, the collimators being mounted on either of two pairs of piers, in the meridian and prime vertical respectively.



The level error would be found by reflection from mercury (nadir observation). The azimuth may be determined by two observations of a circumpolar star, the co-latitude γ being

known. Thus, if P,Z in the figure be the pole and the zenith, S_1 S_2 the two positions of a circumpolar star when it is in azimuth $A' = A + a$, PM an arc perpendicular to ZS_2S_1 and bisecting S_1S_2 in M, the Z.D. z_1 at sidereal time t_1 (corresponding to S_1) and the Z.D. z_2 at sidereal time t_2 (corresponding to S_2) are observed, the observations being corrected for collimation and level and also, if necessary, for change of R.A. and N.P.D. in the interval $t_2 - t_1$.

Then

$$S_1PM = S_2PM = \frac{15}{2}(t_2 - t_1)$$

$$S_1M = S_2M = \tfrac{1}{2}(z_1 - z_2),$$

and the azimuth $A' = A + a$ is given by

$$\cos A' = \tan \tfrac{1}{2}(z_1 + z_2) \cot \gamma.$$

The N.P.D. and R.A. of the star are given by

$$\sin \Delta = \sin \tfrac{1}{2}(z_1 - z_2) \operatorname{cosec} \frac{15}{2}(t_2 - t_1)$$

$$\sin h_1 = \frac{\sin A' \sin z_1}{\sin \Delta}, \quad \sin h_2 = \frac{\sin A' \sin z_2}{\sin \Delta},$$

whence the R.A. a is

$$a = t_1 + \frac{h_1}{15} \text{ or } t_2 + \frac{h_2}{15},$$

This method of determination of azimuth error (as well as of R.A. and N.P.D. of the star) is merely indicated above in general terms, without entering into details of computation.

The azimuth may, if necessary, be found from a single observation of a star if the N.P.D. and the co-latitude are known, or if the hour angle and star's N.P.D. or the co-latitude are known.

In cases where the motion in azimuth or zenith-distance is very slow, the azimuth or Z.D. micrometer may be used to bisect the star (with the middle wire), the instant of bisection being recorded on the chronograph, as in the case of close circumpolar stars with the transit-circle.

It will be seen from the foregoing explanation that such an instrument would be available to determine the R.A. and N.P.D. of the Sun, Moon, planets, and stars out of the meridian with the same accuracy as for a meridian observation, and with little more labour in calculation. The importance of extra meridian observations of the Moon was urged long ago by Sir G. B. Airy and has been generally recognised, and similar observations of the planets would also be of great value for the same reason, viz., the determination of positions in parts of the orbit where daylight prevents the observation of the object on the meridian or where the meridian observation would be some time after midnight, involving a long watch for the observer. The planet *Mercury* may be specially mentioned as an object for observation

out of the meridian, owing to the paucity of meridian observations.

The proposed instrument would also be available for the determination of refraction, latitude, and systematic errors of N.P.D. by comparison of observations of stars and the Sun in different azimuths, and this would, in my view, be a very important application of the instrument. It would, in fact, enable us to determine with the accuracy of a meridian observation the fundamental places of stars under different instrumental and observational conditions, and thus to give independent determinations available for the discussion of refraction, latitude, and systematic errors generally.

When fixed in the meridian, this instrument would be to all intents and purposes a transit-circle, and could be used for all the ordinary meridian observations. I would propose that it should have a telescope of 8 inches aperture and of about 8 feet focal length, with two circles of 3 feet diameter each read by four microscopes, and that the reversing apparatus should lift it sufficiently high to give a clear view for the collimators, without perforation of the central portion, which should be made barrel-shaped, instead of in the usual form of a cube. The object-end and eye-end of the telescope tube should be precisely similar as regards strengthening diaphragms, and the object-glass and eye-piece micrometer should be readily interchangeable, the mode of attachment to the tube being the same for both.

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Note on the History of the Great Sun-spot of 1892 *February.*
By E. W. Maunder.

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Although it was not until the month of 1892 February that this Sun-spot first attracted general attention, this was not its first appearance, for it had been seen during the three preceding months. It was first seen so far back as 1891 November 15, and was not finally lost to sight until 1892 March 17. And as it took its first rise, and underwent final dissipation, whilst in the invisible hemisphere, it was thus watched through the whole of five semi-rotations.

It was only during the February appearance that the group reached exceptional proportions, but during each of the other four appearances it was an important group, and during November it was decidedly above the average of spots at the present time as to size, and showed many features of interest. But the most remarkable feature in its history was the striking and persistent drift in latitude which it exhibited from its first appearance in 1891 November up to the time of its greatest